water). This, with a thickness of eight or ten feet gets piled up by the action of waves and wind, and consequently in the bays of the coast of Labrador it polishes rock bottoms to a depth of fifteen feet or more, below the surface of the water, and grinds off rough surfaces. I have frequently seen, myself, in northern regions, high boulders transported by the ice to which they were frozen in the margin of small lakes.

From what has been written, it seems to the writer that the glacial origin of Lake Ontario does not rest on a single basis further than that ice scratchings (producible by either glaciers or icebergs, neither of which need be great erosive agents) are seen at various places about Lake Ontario, both above and below the water-level. The remarks applied to Lake Ontario hold good for the other lakes. The description of their topography strengthens the proofs that their origin cannot be accounted for by glaciers, because we find the islands at the western end of Lake Erie, or northern end of Lake Huron, polished and striated.

Before closing, permit me to thank those railway companies which have kindly furnished me with many levels. But in doing this, I may state that it is my purpose to make further requests and hope to do for Ontario, what the Pennsylvania Survey has done, in collecting all levels that bear on the topography of my native Province, in order to make a more complete study of the Preglacial drainage of the great lake region.

Geological Section at St. Mary's, Elk County, Pennsylvania. By Charles A. Ashburner, M. S.

(*Read before the American Philosophical Society, March* 18, 1881.)

Introduction. Probably no locality within the Bituminous Coal Fields of Pennsylvania has had so many and such conflicting reports published on its coal geology as the counties of McKean and Elk. Had these reports been made with the desire of merely collecting facts, and of showing their true correlation, we would no doubt long before now have reached the truth in regard to the systematic geology of the coal measures; unfortunately for science, for the geologist and the capitalist, most of the individual investigators have been biassed and prejudiced in their studies, by a natural desire to find favorable facts, from which to deduce conclusions enhancing property values. In many cases true facts have been presented, but as a rule they have not been sufficiently numerous from which to draw conclusions of a correctness beyond question or doubt.

As we look back over the varied history of this region during the past twenty years, examine the reports which have been made, both privately and publicly, note the mineral development of the region, consider the results attained, estimate the profit and loss in money value, and count the benefits accruing to the land owner, the county and Commonwealth, the picture presented is unsatisfactory. The steady, permanent develop-

ment of the coal fields has been misdirected, and consequently retarded. Investments have too often met with disappointment, followed by failures.

A geologist cannot manufacture good coal beds or purify poor ones; and he steps beyond his professional bounds as a practical geologist when he attempts aught else than the discovery of facts and their true economical interpretation.

If there are any advantages to property holders to be derived from too favorable and rose-colored reports, they are certainly only immediate and are insignificant in comparison with the more permanent ones resulting from true, unbiassed and less favorable reports.

I have prefaced my paper with these remarks, because the results of my examinations in the counties mentioned have two direct and important but quite independent bearings; one is purely commercial in its aspects, as it interests and affects the land owner and coal operator; the other belongs to the province of pure geology concerning only the geological investigator and student.

It is my present purpose to merely describe a new interpretation which I have made of the stratification in the vicinity of St. Mary's, Elk County, and to indicate its bearing upon the systematic geology of other portions of the district.

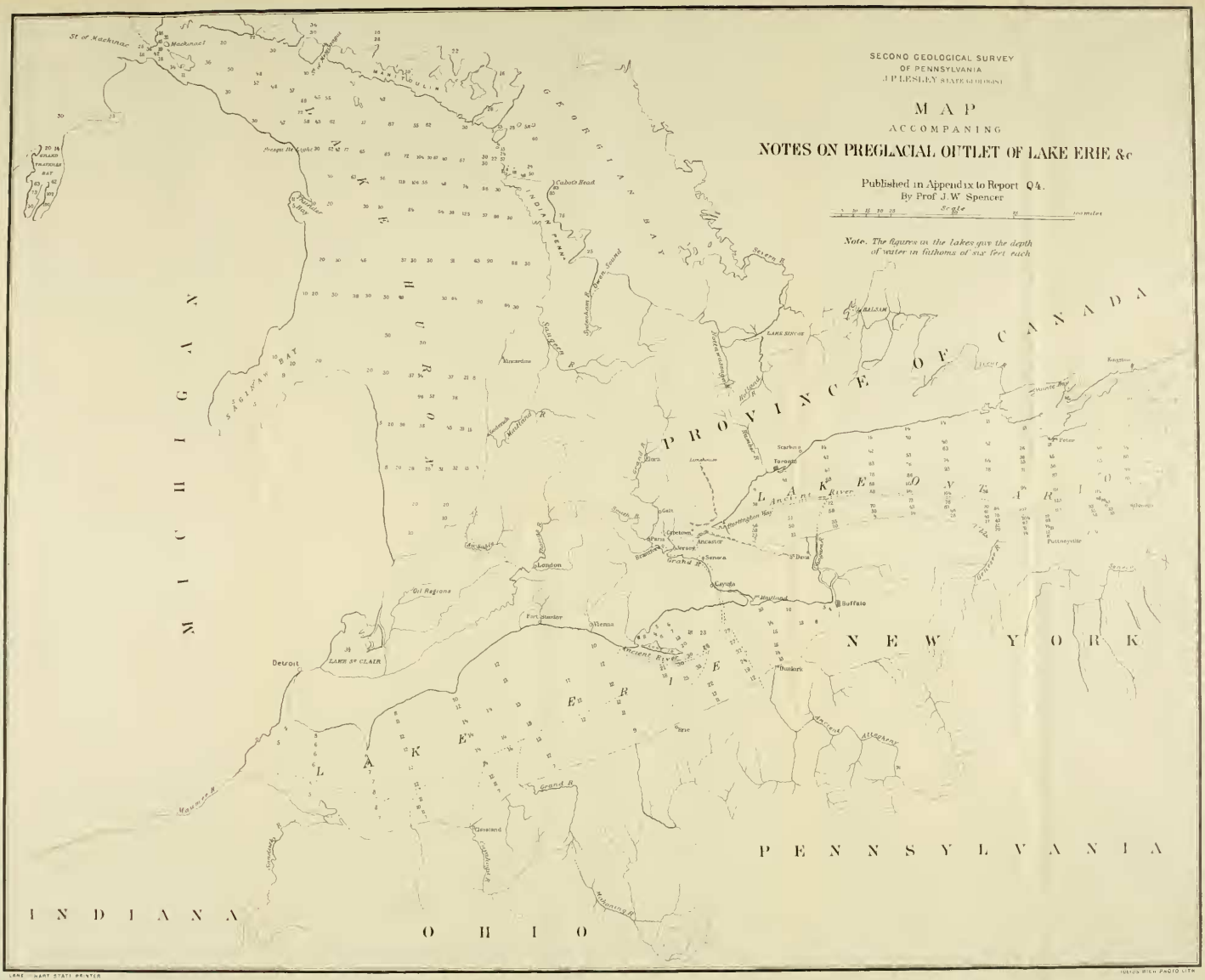
Statement.—The detail geology of McKean has already been published in report R of the Geological Survey; that of Elk will be found in connection with the geology of Cameron and Forest in the forthcoming report RR.

The local geologists of Elk County generally consider the coal measures in the vicinity of St. Mary's to be low in the series; whereas I make them to include the representatives of the Lower Freeport, Kittaning, Clarion and Mercer (or Alton) coal groups.

I fully realize the fact that I am making a statement which is directly opposed to the general views held in regard to the nomenclature of the St. Mary's coal beds. But the most important and difficult problem which I have had to deal with, has been the identification of the coal rocks; and the conclusions which are now advanced have only been reached after a careful detail study of the coal basins of McKean, Cameron, Elk and Forest counties. A great many observations have been made in adjoining counties in order to confirm the work, and connect it with that done by other survey assistants in adjoining fields.

The fact that a rock section contains the representatives of certain well known and established groups, does not necessarily imply that each group has a well defined representation of the individual beds which characterize it at the place of its best development. The special features which have determined the naming of the sub-groups of the coal measures, at their typical locality, may be wanting at many places where the occurrence of the group itself can alone be determined by a comparative study of the entire formation.

From the fact of the St. Mary's section containing the rocks of four of the principal groups of the Lower Productive coal measures in the State,



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the natural inference would be that a number of valuable workable beds should be found here, out of the eight beds which these groups generally embrace, and which have proved so productive in other portions of Pennsylvania. The fact is, however, that at St. Mary's only one coal bed has as yet been found* of sufficient purity and thickness† to be profitably mined *over any considerable area.* This bed is the Dagus or Lower Kittanning coal bed.

But besides this bed the St. Mary's section contains representatives of the Upper and Middle Kittanning, the Clarion and Mercer coal beds; and the ground at the Patton Hill near the west mine of the St. Mary's Coal Company is high enough to contain a very small area of the Freeport Lower coal, although it has not been discovered.

The following is a general section of the coal measures in the vicinity of St. Mary's, compiled from facts obtained within a radius of one and a half miles of the Philadelphia and Erie railroad station. For the sake of completeness I have added to this section the record of the drill hole of the St. Mary's Oil Company, making in all nearly a half mile of vertical thickness of rocks whose character is actually known :

Elk County Section; at St. Mary's.

1.	Gray sandstone, shale and slate	67
2.	Coal, *Kittanning Upper*	3′
3.	Sandy shale and slate	33′
4.	Coal, *Kittanning Middle*	1′ 6″
5.	Sandstone and shale	55′
6.	Coal, *Dagus, Kittanning Lower*	3′
7.	Fireclay‡	3′
8.	Shale	17′
9.	Coal	1′ 4″
10.	Sandstone and shale	10′
11.	Limestone and shale, *Clermont, Ferriferous*	10′
12.	Shale	13′
13.	Coal	5″
14.	Shale	16′
15.	Coal, *Clermont, Clarion*	2′
16.	Sandstone and shale, JOHNSON RUN S. S.	32′
17.	Coal, *Alton Upper*	2′ 7″
18.	Shale	18′

*The Clermont or Clarion bed has been worked to a limited extent on the Monastery lands east of Silver creek, about three-quarters of a mile northwest of the St. Mary's railroad station.

†The degree of purity and extent of thickness necessary to constitute a workable, marketable coal bed, are purely arbitrary, and their values are dependent upon commercial questions.

‡A fireclay bed invariably forms the floor of all our bituminous coal seams. They have not been noted in the section except where their thickness has been determined; in most cases they have been included in the rock interval beneath each coal bed.

PROC. AMER. PHILOS. SOC. XIX. 108. 2Q. PRINTED MAY 3, 1881.

19.	Coal, *Alton Lower*	3′
20.	Sandstone, KINZNA CREEK S. S.	45′
21.	Shale and Coal	10′
22.	Sandstone and conglomerate, OLEAN CONGLOMERATE	50′
23.	Slate, sometimes containing a coal bed 2′ thick	10′
	Total	406′

24.	Grit, clay and gravel (top of St. Mary's drill hole)	18′ to	18′
25.	Sand	18′ "	50′
26.	Interval	45′ "	95′
27.	Sand	25′ "	120′
28.	Interval	140′ "	260′
29.	Sand	16′ "	276′
30.	Interval	124′ "	400′
31.	Sand	20′ "	420′
32.	Interval	205′ "	625′
33.	Red shale, sandstone and slate	335′ "	960′
34.	Interval	12′ "	972′
35.	Sand	49′ "	1021′
36.	Interval	369′ "	1390′
37.	Red sandstone	25′ "	1415′
38.	Interval	35′ "	1450′
39.	Reddish rock	5′± "	1455′
40.	Interval	215′ "	1670′
41.	Sand	44′ "	1714′
42.	Gray and black slate, containing shells and streaks of red	286′ "	2000′
43.	Fine bluish-white sand	10′ "	2010′

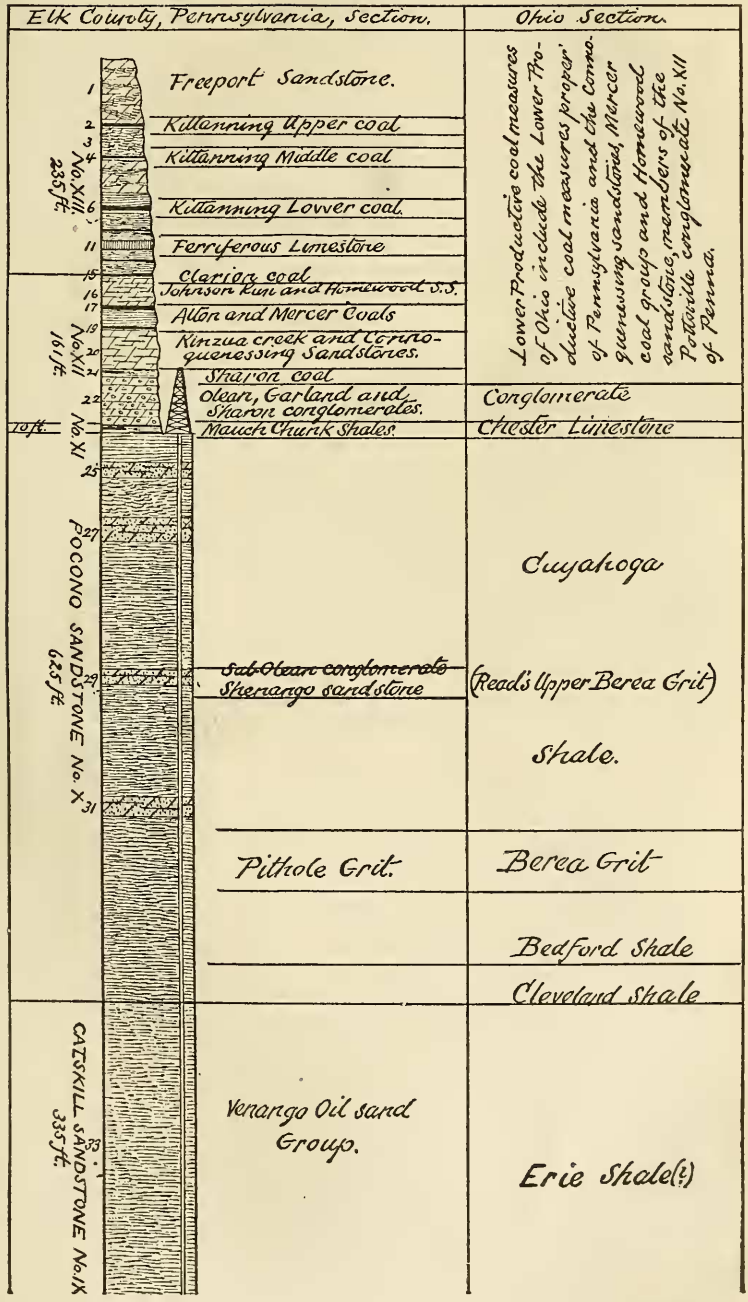
The record of the well is given just as it was reported by Mr. W. W. Ames, who had copied it from the driller's book. The undescribed intervals contained generally gray slate.

A small *gas vein* was struck at a depth of 550 feet; at 972 feet a very much larger one was found. At a depth of 450 feet and 1020 feet salt water was encountered. The geological horizon of the *Bradford Oil sand* is at least 250 feet below the bottom of the St. Mary's test well.

The section may be grouped into formations as follows:

CARBONIFEROUS AGE.

XIII.	Lower productive Coal Measures (1 to 15 incl.)	235′
XII.	Pottsville conglomerate (16 to 22 incl.)	161′
XI.	Mauch Chunk shale (23)	10′
X.	Pocono shales and sandstones (24 to 32 incl.)	625′
	Total	1031′


Elk County, Pennsylvania, section.
Ohio Section.
Freeport Sandstone.
Kittanning Upper coal
Kittanning Middle coal
Kittanning Lower coal
Ferriferous Limestone
Clarion coal
Johnson Run and Homewood S.S.
Alton and Mercer Coals
Kinzua creek and Corniferous Sandstones.
Sharon coal
Olean, Garland and Sharon conglomerates.
Mauch Chunk Shales.
No. XIII. 235 ft.
No. XII 161 ft.
No. XI 10 ft.
POCONO SANDSTONE No. X 625 ft.
CATSKILL SANDSTONE No. IX 335 ft.
Lower Productive coal measures of Ohio include the Lower Productive coal measures proper of Pennsylvania and the Connoquenessing sandstones, Mercer coal group and Homewood sandstone, members of the Pottsville conglomerate. No. XII of Penna.
Conglomerate
Chester Limestone
Cuyahoga
Sub-Olean conglomerate
Sherango sandstone
(Read's Upper Berea Grit)
Shale.
Pithole Grit.
Berea Grit
Bedford Shale
Cleveland Shale
Venango Oil sand Group.
Erie Shale(?)

DEVONIAN AGE.*

IX.	Catskill sandstone and shale (33).....	335′
VIII.	Chemung shale and sandstone (34 to 43 incl.)...	1050′+
	Total.....	1385′
	Total of known rocks.....	2416′

Lower Productive Coal Measures.

This group, which is 235 feet thick at St. Mary's, contains only one coal bed which has proved productive to any great extent.

The rocks of interval No. 1 of the section form the top of the Patton Hill and include the FREEPORT SANDSTONE and possibly the *Freeport limestone* and *Freeport Lower coal bed*, although neither of the latter have been discovered. Ten miles south-west of St. Mary's the *Freeport limestone* is only 40 feet above the Kittanning Upper coal, and the Freeport Lower coal is only 50 feet above the same bed; at St. Mary's the top of the hill is 67 feet above the latter. The total absence of the Freeport coal and limestone here, argues either a disappearance of the beds to the north-east or a considerable thickening of the Freeport sandstone in the same direction.

The *Kittanning Upper coal* (stratum 2) is reported to have been found in a well dug near Patton's house. This is the only place in the township where it has been found. The bed is said to be 3 feet thick, but has never been thoroughly tested.

The *Johnstown cement bed* which occurs between the Kittanning Upper and Middle coals has not been found; it is, however, well defined in the sections of Fox and Horton townships, to the south-west.

The *Kittanninny's Middle coal* (stratum 4), has been found on the Cascade Mining Company's tract (Kaul and Hall). It is only 18 inches thick and not workable.

The *Dagus or Kittanning Lower bed* (stratum 6), is the principal and most important coal. It has been worked in the mines of the St. Mary's Coal Company, Cascade mines, Tannerdale mines, Keystone mines and has been opened and tested on a number of other properties.

This bed is without doubt the same as that which is mined by the North-western Mining and Exchange Company near Centerville, and which is locally called "C" bed and the "Gas Vein," which has been opened by Genl. Kane on the Roberts lot in Jones township.

Objections.—Local geologists have always considered the St. Mary's bed to be very much inferior to these two latter seams. This conclusion, although unquestionably false, has been based upon three very significant facts:

First. The St. Mary's bed is found at a very much lower level than either the "Gas Vein" or the "C" bed at Centerville.

Second. No limestone is found under the St. Mary's bed to correspond

* The Devonian Age here is made to include the Catskill formation, in order to agree with the accepted division of the Palæozoic Period in the Penna. Survey reports. I believe, however, that the Catskill rocks are of Carboniferous age.

with that formed at Genl. Kane's quarry 40 feet under the "gas vein" or 40 feet below the "C" bed on Toby creek.

Third. The St. Mary's bed is rustier in appearance and does not produce as rich a coal as either the "gas vein" or "C" bed, at the same time the floor and roof of the three beds differ materially in the three localities.

Although these are pointed and pertinent objections against the indentity of the three beds, I have not found any facts to sustain them; to the contrary, the weight of evidence, when carefully considered, is directly in support of the conclusion, which after four years of field work I have no hesitancy in asserting, that the coal bed mined by the St. Mary's Coal Company, by the North-Western Mining and Exchange Company and which has been opened on the Roberts lot above the limestone, is in every case the representative of the Lower Kittanning coal bed.

Demonstration.—It is impossible to give as many facts to prove my position in this paper as I shall present in the published volume of the survey, but I think I can answer these objections in a way satisfactory both to myself and reader.

1. The following elevations above tide will show the relative heights of the bed in the three localities:

At St. Mary's it is	1775 feet.
*Near Centerville it is	1835 " †
On the Roberts lot it is	1975 "

These three places are in three different and quite independent coal basins, and it would be unnatural that there should be any fixed or definite relationship existing between their heights. The Roberts lot is in the Fifth Bituminous coal basin and this is separated by a high, broad anticlinal, running in a north-east and north-west direction, east of Ridgway, from the Fourth Basin in which St. Mary's and Centerville are located. The mines at these two latter places are *in different sub-divisions of one main synclinal.*

I think every one acquainted with the facts in the vicinity of St. Mary's and Centerville, will recognize the fact that between the east and west mines of the St. Mary's Coal Company there is a synclinal axis having a north-east and south-west direction, and that the head waters of Toby creek near the mine marks nearly the position of another synclinal axis; that these two axes are not continuations of one another would be evident to any one studying the facts carefully on the ground.

I am aware that this latter conclusion will be vigorously opposed, but I believe it cannot be absolutely denied until more *facts* are brought forward to oppose it, than I have to confirm it.

2. In regard to the *limestones* it seems to be quite certain that the limestones and shales composing an interval of 20 feet, 40 feet below the "gas

* Head of Toby creek. The same coal is 1922 feet, ¼ mile north of the Centerville store.

† On a profile just received from Mr. Oliver W. Barnes, the approximate elevation of the coal bed at the mine of the North-Western Mining and Exchange Company is stated to be 1779 feet. The elevation here given (1835') is based upon the elevation of the road at Centerville, in front of McCauley's store, which, according to Dr. C. R. Earley, is 1963 feet above tide.

vein" on the Roberts lot; the limestone which is 6 feet thick and 40 feet below the "C" bed at Centerville, and the limestone bands and shales 10 feet thick exposed in a railroad cutting one mile east of the coal shutes of the St. Mary's Coal Company, and 31 feet below the St. Mary's bed, are all representations of the *Ferriferous limestone*.

This conclusion is based upon a comparative study of all the individual members of the rock sections in the three localities. On account of the bad exposures in the Johnson run basin in the vicinity of the Roberts lot and along Toby creek, and on account of the limestone in the two places lying low in the valleys, it has always been difficult to determine the rock thicknesses below the limestone. This fact has resulted in each case, of placing the limestone too high in the measures, and consequently an error in the identification.

It is generally believed that no limestone occurs at St. Mary's. On careful search an outcrop of the bed may be found on a hill north-west of the railroad station. I have been told upon good authority that pieces of stone have been gathered here which have been burned into lime. This limestone is the same bed which is shown in Rogers' section (Vol. II, p. 522, Final Report First Survey).

It has been reported that the limestone which was located by the assistants of the First Survey was planted by persons having coal interests, with the view of deception. Neither Prof. Rogers nor his assistants were deceived; the limestone which is placed in the section already noticed occupies exactly the same relative position as that in the accompanying section.

The *Ferriferous limestone* has a variable character throughout Western Pennsylvania, so that a difference in the quality and thickness of the beds in the three localities named do not argue against their identity.

3. The character of the *Dagus* or *Kittanning Lower bed*, together with its flooring and roofing strata, are found to vary considerably within the immediate vicinity of St. Mary's, where its identity may be determined by the engineer's level alone.

The following analyses, made by Mr. A. S. McCreath, show marked variations in the chemical constitution of the coal:

	a.	*b.*	*c.*	*d.*
Water	.990	1.190	1.050	.990
Volatile matter	38.355	33.990	39.295	40.585
Fixed carbon	52.826	50.990	48.001	49.416
Sulphur	2.044	3.118	3.324	3.369
Ash	5.785	10.710	8.330	5.640
	100.000	100.000	100.000	100.000
Color of ash	reddish gray.	lilac.	pink.	pink.
Coke per cent	60.655	64.820	59.655	58 425
Fuel ratio	1:1.37	1:1.50	1:1.22	1:1.22

a. Tannerdale mine, worked by St. Mary's Coal Company, two miles

north-east of St. Mary's. Average thickness of coal 2 feet 6 inches. Coal, dull black, more or less coated with iron oxide; partings of pyrites in very minute crystals partly decomposed.

b. East mine, St. Mary's Coal Company. Average thickness of coal 3 feet 2 inches. Coal, dull black, brittle, iridescent, numerous partings of pyrites and slaty coal.

c. West mine, St. Mary's Coal Company. Average thickness of coal 3 feet. Coal, dull black, more or less stained with iron oxide, rather friable and contains numerous partings of pyrites and slaty coal.

d. Cascade mine, Kaul and Hall. Average thickness of coal 3′ 8″.

Coal, deep black, lustrous and coated with silt; contains considerable pyrites, which is partially decomposed.

For the sake of comparison I have added the analyses of the Roberts lot coal and the coal of the North-Western Mining and Exchange Company at Centerville, and of the *Clermont, Clarion* bed on the Monastery lands:

	e.	*f.*	*g.*
Water	2.460	1.080	.870
Volatile matter	37.990	38.455	37.890
Fixed carbon	52.816	53.190	52.657
Sulphur	.814	1.975	.838
Ash	5.920	5.300	7.745
	100.000	100.000	100.000
Color of ash	yellow.	gray pink tint.	cream.
Coke per cent	59.550	60.465	61.240
Fuel ratio	1 : 1.39	1 : 1.38	1 : 1.39

e. Hoyt opening on "gas vein" Roberts' lot, Jones township. Coal has a dull black luster; cannelly structure; laminæ indistinct; fracture generally irregular, but with a tendency to a cubical.

f. "C mine" North-Western Mining and Exchange Company. Average thickness of coal 3 feet 6 inches. Coal, deep black, lustrous, brittle; shows numerous thin partings of pyrites in minute crystals, partially decomposed.

g. Silver creek mine on Clermont bed, Monastery lands, D. Eldridge operator. Average thickness of coal 2 feet. Coal, deep black, lustrous, brittle, no crystals of pyrites observed. By a comparison of these analyses it will be found that greater differences exist in the composition of the bed in the immediate vicinity of St. Mary's, than between the coal at Tannerdale, Centerville and Roberts' lot, or between the coal from the bed at any one of these three places, and that taken from the Silver creek mine on the Monastery lands.

There is no characteristic *belonging* to the Kittaning Lower coal bed, which may serve as a means for its identification. Where the greatest differences in the composition of the bed exist, as at St. Mary's, the coal can be easily traced and located in the series, by observations made on the

topography; where the composition of the bed is most similar, as at Tannerdale, Roberts' lot and St. Mary's, it requires all the skill and judgment of a trained geologist to determine their geological relationship.

In the east mine of St. Mary's Coal Company the roof is found to change suddenly from a black slate to a hard, massive sandstone. The same thing is reported to have occurred in the now abandoned Keystone mine.

Conclusion.—In view of these facts as regards the variation of the composition of the Dagus or Kittanning Lower coal bed and the changes which are liable to occur in the associated strata within a small area, similar differences at localities so far removed from one another as St. Mary's, Centerville and Roberts' lot, can certainly have but little weight in determining the relative position of the beds.

The best and most reliable means of ascertaining the connection existing between distant rock sections is, by making *a comparative study of sections in their entirety.* A marked similarity will oftentimes be found to exist between the general structure of each section, even where no persistency of character is found to exist between the minor features.

Clermont Group.—The *Clermont** or *Ferriferous limestone* has a distinct and well recognized representative in the vicinity of St. Mary's. The horizon of the limestone is 30 feet above the *Clermont* or *Clarion* coal bed. As has been said, pieces of the stone were found along its outcropping level on the hill north-west of the town.

In a railroad cutting two miles north-east of St. Mary's station, and extending from mile-post 130 to 130+500 feet, is found exposed the representative of the Ferriferous limestone. It consists of gray and black shale and slate containing bands a few inches thick of limestone and lime balls, heavily charged with iron. No limestone has ever been found in the Fourth Basin north-east of St. Mary's.

The *Clermont* or *Clarion coal bed* (stratum 15), marks the top of the Carboniferous or POTTSVILLE CONGLOMERATE, No. XII. This is the position usually occupied by the Brookville coal bed, but I failed to recognize its representative any where within my district of four counties. The best illustrations and discussion of the variations of the Clarion and Brookville coal beds and of the underlying Homewood or Kinzua creek sandstone may be found in the Clarion county report by Dr. H. Martyn Chance.

Alton Group.—The position, extent of area and character of the Clermont and Alton group coals is a matter of considerable importance to the coal interests centered about St. Mary's. No geological report can settle the question in a practical way. That the coal beds should exist, *if the strata were perfectly regular*, I can positively assert; that they do not exist at every point, has been practically proven. The strata are liable to change, and it must be left to explorations of the drift, the drill-hole and the shaft, to test practically the economical value of these coal beds.

* *Clermont* is a local geographical name which I gave to this limestone in McKean and Elk counties, its use was only adopted provisionally until its identity with the *Ferriferous limestone* of Western Pennsylvania should have been placed beyond a doubt.